NEW NEBULÆ.—M. Stephan publishes positions and descriptions of 100 nebulæ discovered at Marseilles in the years 1883–85, in addition to the large number previously detected at that observatory. Not the least notable characteristic of M. Stephan's catalogues is the precision of the places given in them. He mentions that on October 1 and 2, 1882, neither the nebula Dreyer-Schultz 5085 nor *h* 12 were perceptible in the positions assigned to them by the discoverers.

ASTRONOMICAL PHENOMENA FOR THE WEEK, 1885, *MAY* 17–23

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on May 17

Sun rises, 4h. 7m.; souths, 11h. 56m. 10·8s.; sets, 19h. 46m.; decl. on meridian, 19° 26′ N.: Sidereal Time at Sunset, 11h. 29m.

Moon (at First Quarter May 21, 6h.) rises, 6h. 59m.; souths, 14h. 53m.; sets, 22h. 44m.; decl. on meridian, 18° 7′ N.

Planet	Rises h. m.	Souths h. m.	Sets h. m.	Decl. on meridian ° ′
Mercury	3 37	10 30	17 23	9 41 N.
Venus	4 18	12 10	20 3	19 55 N.
Mars	3 24	10 36	17 48	13 13 N.
Jupiter	11 0	18 15	1 30*	13 38 N.
Saturn	5 43	13 51	21 59	22 18 N.

* Indicates that the setting is that of the following day.

Occultations of Stars by the Moon

May	Star	Mag.	Disap. h. m.	Reap. h. m.	Corresponding angles from vertex to right for inverted image ° °
19	α Cancri	4	22 52	23 15	48 359
21	B.A.C. 3407	6	0 21	1 12†	125 276
21	35 Sextantis	6	20 48	21 18	26 340

† Is below horizon at Greenwich.

Phenomena of Jupiter's Satellites

May	h. m.		May	h. m.	
17	23 21	II. occ. disap.	21	0 21	I. occ. disap.
19	20 28	II. tr. egr.		21 41	I. tr. ing.
20	21 33	III. occ. reap.	22	0 1	I. tr. egr.
	23 10	III. ecl. disap.		22 22	I. ecl. reap.

The Occultations of Stars and Phenomena of Jupiter's Satellites are such as are visible at Greenwich.

May 21, 3h.—Jupiter in conjunction with and 4° 17′ north of the Moon.

THE IRON AND STEEL INSTITUTE

THE Iron and Steel Institute met on Wednesday, the 7th inst., when Dr. Percy gave the presidential address. After inviting the co-operation of the members in supplying him with materials for the new edition of his work on "Iron and Steel," and referring to Mr. Lowthian Bell's recent valuable work on the same subject, Dr. Percy drew attention to the existing universal depression, due, in his opinion, to over-production. "Darwinianism prevails in the manufacturing world as it does in the natural world, however painful and unwelcome may be that truth—only the fittest will survive. The struggle may be severe and to many persons disastrous, but so long as supply exceeds demand, it is inevitable, and the result is not doubtful."

In the matter of technical education he regretted that a few of its professed friends should have indiscreetly attempted to imbue all our artisans with the notion that the one thing which at present they urgently need is technical education, and that it will be certain to benefit them all alike, whereas in some trades, such as that of the file-cutter, the marvellous skill which is alike the surprise and admiration of all is to be obtained only by the practice of his art. He referred with pleasure to the judicious and enlightened way in which Sir Bernhard Samuelson, M.P., had advocated technical education in its widest sense, and rejoiced over the liberality of the founders of the Owens College (now the Victoria University) in Manchester, the Mason College in Birmingham, and the Firth College in Sheffield, and of the Whitworth Scholarships, through whose aid scientific instruction is placed within the reach of the artisan class.

The major portion of the address was devoted to the physical and chemical properties of iron and steel, and the learned President's remarks brought out in strong relief the prevailing want of knowledge. How comes it, he inquires, that the force of cohesion should be increased by mechanical treatment, which, *à priori*, might be supposed would tend in greater or less degree to produce disaggregation? Why is iron or steel wire increased in strength by wire-drawing? What is the cause of the physical changes which some metals and alloys have been observed to undergo spontaneously while at rest and under ordinary atmospheric conditions?

"It is not many years since that we had to grope about to discover an analysis of iron ore or of pig iron, whereas now we are actually overwhelmed with such analyses. We are deluged with percentages of carbon, graphitic or combined, of silicon and manganese, of sulphur and phosphorus. We are bewildered by this vast accumulation of material. What is now wanted is the man to reduce it to law and order, to evolve from it principles for our sure guidance. But the problem is so intricate and complex that no common brain can solve it. What are the physical properties of pure iron after fusion? What are the chemical and physical properties of compounds of pure iron and pure silicon in various proportions? What are the modes of existence of manganese, silicon, and phosphorus when present together in pig iron? What is the *modus operandi* of manganese in the manufacture of iron and steel? Why are animal matters or certain other substances rich in nitrogen, required in case-hardening iron? Is any nitrogen or any compound of it imparted to the case-hardened part of the iron? These and such like questions the metallurgist asks of the natural philosopher and chemist, and has failed hitherto to receive a reply."

Having concluded what may be called the technical part of his address, Dr. Percy treated the question of the extent to which the Government of a country should engage in manufacture, and stated "that, if it could be shown that the people as a whole would be benefited by the Government's engaging in manufacture, then the Government was bound to take that course." Treating the various cases of armour-plates, steel for guns, and steel for ship-plates, he showed that in each case, owing to competition, co-operative management, and other causes, private industry was always able to produce articles as good as and cheaper than the Government.

The address was listened to with the greatest attention throughout, both on account of the inherent interest of the matter and the great oratorical skill employed in its delivery. The closing paragraphs are of such universal interest that we quote them verbatim:—

"Everything in this world, nay, there is reason to believe everything in the universe itself, is changing from moment to moment. There is, as I have stated in print long ago, nothing constant but change, however paradoxical that statement may appear. Every drop of rain that falls, for instance, exerts a levelling action on the hills and mountains, and carries down with it in its course to the ocean a minute yet sensible portion of earthy material. In the moral world the like incessant change is going on, and no one can predict what the final result of that change will be. Our globe may, it seems to me, be fitly compared with the laboratory of the philosopher. The one, to our finite understandings, may appear the scene of social and political experiments, just as the other is the scene of chemical and physical experiments. But of this we may be sure, that invariable and irresistible law guides all things, immaterial as well as material. When I reflect on the intricate social problems of the day, the solution of which excites dread in the minds of many, I fancy I see the social molecules, if I may use such an expression, actively at work in rearranging and adjusting themselves to new conditions, and producing results as surprising as they are remarkable. The mysterious forces, whatever they may be, which regulate the movements of those molecules, are as certain in their operation as those which determine the course of the planets in their orbits. Both are equally uncontrollable by the agency of man, and politicians will in vain struggle against them.

"There is a question that must often occur to us, namely, what will Great Britain be when our vast reservoir of material force, coal, is exhausted—a result which many members of the Iron and Steel Institute are doing their utmost to accelerate? The time must come when, in consequence of that exhaustion, Great Britain will cease to be a great manufacturing nation, unless some new source of force should be discovered, which there is

not the least reason to anticipate. But, as I wrote many years ago, however mournful and unwelcome this proposition may be, we have the satisfaction of knowing that we are now laying the foundations of prosperous and mighty kingdoms in various parts of the world, which we hope will be the strongholds of virtue, of order, and of freedom. When our great manufactories shall have crumbled into ruins, and their sites have become green pastures or golden corn-fields, the old country may yet be precious in the eyes of her children. Every spot of her soil will be classic, and command reverential respect. There is no other land more worthy of everlasting remembrance, whether as to its heroes, its poets, its philosophers, its statesmen, or its philanthropists. The glory of Old England may, after all, not depart. On the sites of her soot-stained Birminghams and Manchesters, new and splendid cities may arise, where the merchant-princes of Anglo-Saxon descent, from the remotest regions of the globe, shall rejoice to dwell and end their days in peace."

After the address the President presented the Bessemer Medal to Mr. Lowthian Bell for delivery to Prof. Åkermann, after which the papers were read. The first paper read was that of Mr. Lowthian Bell, on "The Blast-Furnace Value of Coke, from which the Products of Distillation from the Coal used in its Manufacture have been collected." The experiments which formed the foundation of the paper were made upon the same coal coked in the beehive and Simon Carvé's oven, the total quantity of coke operated upon being 5605 tons; it was found that the beehive coke was about 10 per cent. more economical, although the other was 13·83 per cent. denser. In order to ascertain the cause of the inferiority, samples were finely ground and analysed. Similar samples were exposed for half an hour to the full heat—sufficient to soften porcelain—of a gas blast-furnace, access of air being excluded by placing the crucible containing the sample within a larger one and covering it with charcoal. From the loss of weight and the analysis of the original and residual coke, and from the previously-ascertained moisture, it was found that 5·23 per cent. of the Simon Carvé's coke was expelled by ignition, and 3·27 per cent. of the beehive. This accounts for an inferiority of 1·96 per cent. only out of about 10 per cent. It is, however, a well-known fact that certain forms of carbon are less easily burnt than others, and the author sought to account for the superiority of beehive coke in this manner, and found it to be due to the less solvent action of carbonic acid upon it.

At the Wednesday evening meeting Dr. H. C. Sorby, F.R.S., gave an account of his microscopical examination of the structure of iron and steel. His results were based upon the examination of flat surfaces, carefully ground and polished, as the study of fractured surfaces is unsatisfactory, not only on account of optical difficulties, but because a fracture shows the line of weakness between the crystals and not their internal structure. In some cases the surfaces were acted upon by very dilute nitric acid to develop the structure; in others it was found best to polish with dry rouge on parchment, and not to use acid. Thin glass covers were afterwards mounted over the surface with Canada balsam. The objects thus prepared were examined by means of two special kinds of surface illumination, viz. first the side parabolic reflector now common, but which the author believes was originally made for this purpose, which gives oblique light; and secondly, by means of a small silver reflector covering half the object-glass, which throws the light directly down on the object, from which it is reflected back through the other half of the lens. With oblique illumination a polished surface looks black, but, with direct, bright and metallic. A truly black substance looks black in both cases. A magnifying power of about sixty linear is most generally suitable, but the sections will bear a higher perfectly well. The lecturer exhibited photographs and drawings of the microscopic appearance of the surfaces, the peculiarities of which he described.

The following is a summary of some of the chief results:—Iron containing little or no carbon, and of uniform character, shows little, if any change, when acted upon by dilute acid, and no well-marked structure is developed. Hammered blooms show an intimate mixture of varying crystals of iron, with minute or larger portions of slag. In iron bars rolled *hot*, the slag is drawn out into long thin rods, which in some cases are so numerous as to form a very considerable portion of the whole bulk, whilst the iron shows no elongation of the ultimate crystals, the metal apparently recrystallising on cooling. When hammered *cold*, the crystals are compressed, broken up, and elongated in the line of the bar. Many specimens of malleable iron show clearly that two constituents are present, viz. iron, and a compound of iron and carbon, which has a pearly structure; one of these is like the main constituent of such bar iron as contains little or no carbon, having no trace of linear marking, after being acted upon by dilute acid, whereas the other constituent shows linear markings, varying in distance, but often about 1-20,000th of an inch apart, which, when the acid has acted to a proper extent, gives rise to all the splendid colours of mother-of-pearl, the tints being raised when the section is seen in water, and still more so when mounted in balsam. By oblique and direct illumination the colours are nearly complementary. Swedish iron partly converted into blister steel by cementation, shows a mixture of well-formed crystals of free iron and of the pearly compound in the centre; around this a ring of the pearly compound, with colours of great variety and beauty; whilst on the outside is a part in which occurs a network of veins of an extremely hard substance, giving an intensely brilliant reflection and no trace of colour, which seems to contain more carbon than the pearly constituent. The three constituents just described are totally distinct from one another. There is no more passage from one to the other than there is between the mica, felspar, and quartz of granite.

The varying character of ingots of soft and hard steel to a great extent depends on the varying proportion of the three principal constituents. Soft Bessemer steel is seen to be a mixture of free iron and the pearly compound. In medium steel this latter occurs almost alone, whereas in hard steel there is little, if any, free iron, but numerous thin plates of the very hard compound. Besides these three constituents in steel, the microscope gives evidence in cast-iron of the presence of graphite and silicon. The specimen of spiegeleisen studied, consisted mainly of the intensely hard compound, crystallised in large plates, the inter-spaces being filled up with a mixture of very much smaller crystals with a little of the pearly substance, so as to have a most beautiful and fine-grained structure. Taken, then, as a whole, the various kinds of iron and steel are seen to be varying mixtures of three or four out of six or seven substances having very different properties, viz. free iron, the pearly compound with carbon, the intensely hard compounds, probably with more carbon; the residual, probably variable, substance; graphite; possibly crystallised silicon; slag, including fused iron oxide.

On the second day the attention of the meeting was occupied with the subject of the coking of coal by different processes and the recovery of bye-products. Mr. Head's paper contained a description of a modified form of the Siemens old type gas-producer, in which the latter result is effected by dividing the gas-producer by means of a vertical wall into two compartments, one of which receives the hydrocarbons—the volatile constituents of the coal—and the other the carbonic oxide formed by the decomposition of its solid carbonaceous matter. Two other papers referred to results obtained in connection with the Simon-Carvé's coking process. Prof. Armstrong's note with reference to the methods proposed for coking coal and recovering volatile matter has much scientific interest, and we propose to refer to it shortly. The problem consists in as complete a recovery as possible of the matters latent in coal, in the most economical manner and advantageous forms, the treatment depending upon the class of coal acted upon. The author considers the compounds in coal to be mainly of two kinds—phenolic compounds, which are the primary source of the phenols (carbolic acid, &c.) contained in coal tar; and paraffinoid compounds, capable of yielding hydrocarbons such as are obtained on distilling shale; the high-temperature tars such as are obtained at gas-works, not being primary but secondary products of distillation, may be considered final products, the quality of which it will be impossible to improve, whereas the object should be to produce low-temperature tars, which by after-treatment might be made to produce a large proportion of benzene and other valuable products.

The author's idea of a theoretically perfect coking oven is one more or less like the present beehive, with the upper part extended. Heat should be *radiated* upon the surface of the charge of coal, which would soon become coked, thus forming a protecting layer, below which distillation would take place, the products of distillation being sucked away as rapidly as possible through the cool bottom of the oven. The products of combustion which penetrate below would carry no oxygen with them. On this account, and on account of the large volume of steam and other gases generated within the mass, and of the low temperature, the ammonia would probably almost entirely escape destruction. The gas would be of low illuminating quality, but

would be available for carbonising, oil and ammonia being removed from it by efficient scrubbing. The author was of opinion that nothing was known practically of what happens when coal is distilled, and that the coking of coals and manufacture of gas were now only empirical operations, and could not be conducted scientifically, with our present imperfect knowledge, but that the interests involved were so great, the subject being one of national importance, that failure to initiate and execute the necessary systematic experiments without further loss of time would be inexcusable.

On the last day of the meeting Mr. Carnegie's paper on "Natural Gas Fuel and its Application to Manufacturing Purposes" was read. This fuel is found in the Pittsburg district, and one of the wells is estimated as yielding 30,000,000 cubic feet of gas in the twenty-four hours; the pressure of the gas as it issues from the mouth of the well is about 200 lbs. to the square inch, and even at the works, nine miles from the wells, it is 75 lbs. per square inch. Eleven lines of pipe convey the gas from the various wells to the manufacturing establishments in and around Pittsburg. The number of men whose labour will be dispensed with when gas is generally used is 5000. In the steel-rail mills, for instance, where before would have been seen thirty stokers, stripped to the waist, firing boilers which require a supply of about 400 tons of coal in twenty-four hours—ninety firemen in all being employed, each working eight hours—there would now be found one man walking around the boiler-house, simply watching the water-gauges, and not a particle of smoke is to be seen.

Dr. Hermann Wedding's paper on "The Properties of Malleable Iron deduced from its Microscopic Structure" draws attention to the value of microscopic analysis, as, though the chemical and physical properties of iron are closely connected, the one cannot be directly deduced from a knowledge of the other, nor do either of these aid in acquiring a knowledge of the mechanical properties. The pieces of iron to be tested are carefully polished, and then etched with very dilute nitric acid. After etching, the section is carefully heated, whereupon the portions attacked acquire varying tints, mostly golden-yellow, purple-red, violet, or dark blue. It is the difference of colour that is characteristic. As regards the formation of grains and fibres, the size of grain increases with slowness of cooling, and decreases with increase in the proportion of carbon up to 2 per cent. Each individual grain in malleable iron is ductile, the malleability of the entire piece depending on that of the separate grains, which are drawn out into fibres; the strength of fibrous iron depending on the fact that, like the individual hemp-fibres in a rope, the fibres lie with their ends in various sections. The microscope shows, further, that none of these wires or fibres is directly connected with its neighbours, either in a longitudinal or lateral direction. In fact each fibre may, by careful etching, be picked out like those of a muscle in the human body. The paper treats also of the constitution of individual iron crystals and of welding. The general result of the analysis shows that the strength of a finished piece of iron depends on the sectional area of the mass of iron it contains, the slag inclusions in weld-iron and blow-holes in ingot-iron being deducted.

It was announced that the autumn meeting of the Institute would be held at Glasgow.

SUNLIGHT AND THE EARTH'S ATMOSPHERE[1]

II.

WE have been compared to creatures living at the bottom of the sea who frame their deceptive traditional notions of what the sun is like from the feeble changed rays which sift down to them. Though such creatures could not rise to the surface, they might swim up towards it, and if these rays grew hotter, brighter, and bluer as they ascended, it would be almost within the capacity of a fish's mind to guess that they are still brighter and bluer at the top.

Since we children of the earth, while dwelling on it, are always at the bottom of a sea, though of another sort, the most direct method of proof I spoke of, is merely to goup as far as we can and observe what happens, though as we are men, and not fishes, something more may fairly be expected of our intelligence than of theirs.

We will not only guess, but measure and reason, and in particular we will first, while still at the bottom of the mountain, draw the light and heat out into a spectrum, and analyse every part of it by some method that will enable us to explore the invisible as well as record the visible. Then we will ascend many miles into the air, meeting the rays on the way down, before the sifting process has done its whole work, and there analyse the light all over again, so as to be able to learn the different proportions in which the different rays have been absorbed, and, by studying the action on each separate ray, to prove the state of things which must have existed before this sifting—this selective absorption—began.

It may seem at first that we cannot ascend far enough to do much good, since the surface of our aërial ocean is hundreds of miles overhead; but we must remember that the air grows thinner as we ascend, the lower atmosphere being so much denser, that about one-half the whole substance or mass of it lies within the first four miles, which is a less height than the tops of some mountains. Every high mountain, however, will not do, for ours must not only be very high, but very steep, so that the station we choose at the bottom may be almost under the station we are afterwards to occupy at the top.

Besides we are not going to climb a lofty lonely summit like tourists to spend an hour, but to spend weeks; so that we must have fire and shelter, and above all we must have dry air to get clear skies. First I thought of the Peak of Teneriffe, but afterwards some point in the territories of the United States seemed preferable, particularly as the Government offered to give the Expedition, through the Signal Service, and under the direction of its head, General Hazen, material help in transportation and a military escort, if needed, any where in its own dominions. No summit in the eastern part of the United States rises much over 7000 feet, and though the great Rocky Mountains reach double this, their tops are the home of fog and mist, so that the desired conditions, if met at all, could only be found on the other side of the Continent in Southern California, where the summits of the Sierra Nevadas rise precipitously out of the dry air of the great wastes in lonely peaks, which look eastward down from a height of nearly 15,000 feet upon the desert lands.

This remote region was, at the time I speak of, almost unexplored, and its highest peak, Mount Whitney, had been but once or twice ascended, but was represented to be all we desired could we once climb it. As there was great doubt whether our apparatus, weighing several thousand pounds, could possibly be taken to the top, and we had to travel 3000 miles even to get where the chief difficulties would begin, and make a desert journey of 150 miles after leaving the cars, it may be asked why we committed ourselves to such an immense journey to face such unknown risks of failure. The answer must be that mountains of easy ascent and 15,000 feet high are not to be found at our doors, and that these risks were involved in the nature of our novel experiment, so that we started out from no love of mere adventure, but from necessity, much into the unknown. The liberality of a citizen of Pittsburgh, to whose encouragement the enterprise was due, had furnished the costly and delicate apparatus for the expedition, and that of the trans-continental railroads, enabled us to take this precious freight along in a private car, which carried a kitchen, a steward, a cook, and an ample larder besides.

In this we crossed the entire continent from ocean to ocean, stopped at San Francisco for the military escort, went 300 miles south so as to get below the mountains, and then turned eastward again on to the desert, with the Sierras to the north of us, after a journey which would have been unalloyed pleasure except for the anticipation of what was coming as soon as we left our car. I do not indeed know that one feels the triumphs of civilisation over the opposing forces of Nature anywhere more than by the sharp contrasts which the marvellous luxury of recent railroad accommodation gives to the life of the desert. When one is in the centre of one of the great barren regions of the globe, and, after looking out from the windows of the flying train on its scorched wastes for lonely leagues of habitless desolation, turns to his well-furnished dinner-table, and the fruit and ices of his desert, he need not envy the heroes of Oriental story who were carried across dreadful solitudes in a single night on the backs of flying genii. Ours brought us over 3000 miles to the Mojave desert. It was growing hotter and hotter when the train stopped in the midst of vast sandwastes a little after midnight. Roused from our sleep, we stepped on to the brown sand and saw our luxurious car roll away in the distance, experiencing a transition from the conditions of civilisation to those almost of barbarism, as sharp as could well be imagined. We

[1] Lecture delivered at the Royal Institution, April 17, 1885, by S. P. Langley. Communicated by the author. Continued from p. 20.